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***Firefighter Thermal Exposure Workshop:  
Protective Clothing, Tactics, and Fire  
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## **Firefighter Protective Clothing**

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Modern protective clothing (turnout gear) worn by firefighters during the course of attacking a building fire is intended to encapsulate the individual and provide protection from the thermal environment -- thermal radiation, hot gas (convective heat transfer) and contact with hot surfaces (conductive heat transfer). The current turnout gear design is based on years of field experience and some research, carried out most actively during the past 25 years. While the primary consideration has been thermal protection, other issues relating to comfort and physical stress also have been evaluated in garment design.

The space around a firefighter can be thought of as the interaction of three zones. First is the fire environment which can represent a broad range of thermal conditions associated with various fire sizes, incipient fire to post-flashover fire conditions. This environment also can contain high concentrations of numerous products of combustion most notably carbon dioxide, carbon monoxide, and water. The second zone is the protective clothing worn by the firefighter. This barrier is intended to provide thermal protection as well as protection from physical injuries -- cuts, abrasion, and puncture wounds. The third zone is the individual's body. The body is a self-regulating system that attempts to maintain a steady body temperature of approximately 37 °C (98.6 °F). The evaporation of body sweat is the major mechanism used to reduce the impact of an increase in the thermal load on the body. A reduction in the efficiency of sweat evaporation can lead to heat stress.

As a total system the interaction of these three zones need to be understood in order to effectively design protective clothing that provides adequate thermal protection and allows the self-regulating nature of the human body to function properly.

Numerous studies have been conducted evaluating thermal protection of fabric and fabric combinations from various types of fire loads. These studies have led to the development of TPP (Thermal Protection Potential) measurements. Several studies have been performed using instrumented professional firefighters to record the thermal environment a firefighter is exposed to during the course of fire fighting activities. This is not necessarily the same as the thermal load a fire places on a structure. Most investigators have recognized the interaction of the outside environment and body stress. Some have even attempted to measure these in the field. These investigators have attempted to make field measurements that included the thermal and cardiac state of the individual firefighter along with an assessment of the outside thermal environment.

A projected task for this study is to extend the current measurement database created by previous researchers by developing an improved set of measurement tools for characterizing not only the thermal environment around a firefighter, but the thermal state of the turnout gear and the heat stress

experienced by individual firefighters. Measurements planned for this study include: total heat flux incident on the firefighter, the thermal condition of each layer of the turnout gear, the thermal and moisture environment between the turnout gear and the firefighter's body, and the thermal condition of the firefighter as a result of the combination of the external environment and the turnout gear.